Characterizing, Predicting, and Modeling Water from Mine Sites

Day 1: ADVANCED ACID GENERATION, MINE SITE OVERVIEW, MINE SITE CHARACTERIZATION

1. Course/instructor introductions and announcements (Maest; all instructors)
2. Hardrock mines (Maest)
   a. Phases of mining
   b. Types of mines and sources of contamination (open pits, underground workings, waste rock, tailings, heap and dump leach operations, slag)
   c. Contaminants of concern at hardrock mine sites
   d. Transport of contaminants from mining sources
3. Overview of geology, hydrology, geochemistry, and biology of mine sites
   a. Geologic aspects (Alpers, Nordstrom)
      i. Basic geologic properties (lithology, alteration, mineralogy, geomorphology)
      ii. Type/size/setting of mineral deposits
   b. Hydrologic aspects (Travers)
      i. Basic hydrologic properties
      ii. Water balance
      iii. Recharge/flowpath/discharge
   c. Overview of geochemistry (Nordstrom)
      i. Basic geochemical processes (precipitation/dissolution, complexation, acid/base, adsorption/desorption, oxidation/reduction)
      ii. Acid generation and metal solubility from mineral sulfide oxidation
   d. Biological resources (aquatic biota, vegetation, terrestrial wildlife, livestock, humans) (Nordstrom)
4. Site characterization
   a. Objectives of characterization (Maest)
   b. Sample quantity, sample frequency, heterogeneity (Maest)
   c. Baseline and pre-mining or "background" water/soil/biological chemistry (Nordstrom)
   d. Characterization of site hydrology (Travers)
   e. Geochemical characterization methods (Alpers, Maest)
      i. Lithology and alteration zones (Alpers)
      ii. Whole rock analysis (Alpers)
      iii. Mineralogy (Alpers)
      iv. Sulfur analysis (Maest)
      v. Static testing (Maest)
      vi. Short-term leach tests (Maest)
      vii. Kinetic testing (lab and field, scaling issues, use in models) (Maest)
      viii. Guess the pH – contest rules (Alpers)
   f. Characterization during different phases of mining (Kuipers)
5. Monitoring
   a. Before, during, after mining (Kuipers)
   b. Independent; timing, climate, seasonality (Maest) (not presented because of time constraints, but included in Water Board website materials)

Day 2: MODELING
1. Introduction to modeling: Why model? Is modeling needed? Definitions and general steps (Nordstrom, Travers)
2. Conceptual models: Conceptual model development; elements of a conceptual model; examples of conceptual models; flawed conceptual models (Nordstrom, Travers)
3. From concept to quantification
    a. Computer programs (codes) as conveyors of models (Nordstrom, Travers)
        i. Model inputs – field, lab, estimates: Which inputs are most important or equivocal?
        ii. Model outputs – how do they look?
    b. Geochemical databases (Nordstrom)
    c. Types of models and codes available (Travers, Alpers, Nordstrom)
        i. Physical/hydrologic (Travers)
        ii. Geochemical (Alpers, Nordstrom)
        iii. Coupled (Nordstrom, Travers)
4. How confident are we in modeling results? (Nordstrom, Travers)
    a. Calibration, sensitivity analysis, error propagation, standard reference test cases, model documentation (Travers, Nordstrom)
    b. Model uncertainty (Travers, Nordstrom)
        i. Sources of uncertainty
        ii. Recommendations for improvement
        iii. Revisiting modeling as mine plan changes
    c. Model evaluation (Nordstrom)
5. Examples of modeling: How is modeling used? Mine unit modeling
    a. Example 1: Diavik Project, Canada – waste rock and tailings (Nordstrom)
    b. Example 2: Eagle Project, Michigan – underground mine and waste rock (Maest)
    c. Example 3: Summitville, Colorado – surface water quality and baseline (Nordstrom)
    d. Example 4: Robinson Mine, Nevada – groundwater modeling study (Travers) (not presented because of time constraints, but included in Water Board website materials)
6. Preview of fieldtrip to Jamestown Mine
    a. Fieldtrip stops (Alpers, Humphreys)
    b. Regulatory framework (Izzo)
    c. Hydrologic modeling of the Harvard Pit (Isham, Mullenmeister)
    d. Geochemical modeling of the Harvard Pit (Ashley).
7. Guess the pH – results (Alpers)

Day 3: SITE TOUR OF JAMESTOWN MINE
The site tour will highlight major mine waste management features at the Jamestown Mine (now undergoing closure) and the mine pit lake. The instructors will discuss what tests and modeling were done and how predictions compare with actual site conditions.

Course materials include fieldtrip handout (Alpers, Humphreys, Ashley, Isham) and posters of reclamation of the Jamestown Mine (Isham).

Day 4: USE OF PREDICTION INFORMATION IN MINE PERMITTING AND CASE STUDIES

1. Environmental Impact Statement analysis
   a. NEPA/CEQA and water quality predictions (Kuipers)
   b. Overview of EIS Predictions Study (Kuipers)
   c. Results of EIS Predictions Study, inherent factors affecting operational water quality, and CA Mine case studies (Maest)
   d. Root causes of water quality impacts (Kuipers)
      i. Characterization failures (hydrologic and geochemical)
      ii. Mitigation failures
2. Water quality predictions and impacts at mines: Case studies (Maest, Kuipers, Hillenbrand)
   a. Case studies: Comparison of predicted and actual impacts at U.S. hardrock mines and causes of prediction errors (Maest, Kuipers)
      i. Beal Mountain, MT (Au, Ag; open pit heap leach) (Kuipers)
      ii. Stillwater, MT (PGM; underground, flotation) (Kuipers)
      iii. Phoenix, NV (Au; different financial assurance based on different predictions) (Kuipers)
      iv. Buckhorn Mountain, WA (new Au; underground, no ore processed on site) (Maest)
      v. Emigrant, Nevada (Newmont) case study: Comparison of kinetic and static test results (Hillenbrand)
      vi. Royal Mountain King, California (Kuipers)
3. Round-table discussion: Course conclusions and summary (moderated by Humphreys)
   a. Questions regulators can ask about modeling efforts – How can regulators deal with large quantities of modeling results and know whether the modeling is valid or appropriate or necessary? (Nordstrom)
   b. Top ten ways to underestimate impacts – How can regulators deal with mammoth reports on mine characterization and modeling and potential environmental impacts? (Maest)
   c. Discussion of other issues as requested.